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UNITED STATES DEPARTMENT OF THE INTERIOR
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FISH SCHOOLS AND BIRD FLOCKS IN THE CENTRAL PACIFIC OCEAN, 1950-1961

By

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ABSTRACT

This report contains a summary of the results of visual observations of bird flocks and fish schools in a portion of the central Pacific Ocean bounded by latitudes 20° S. and 30° N., and longitudes 110° W. and 180°. Observations made by biologists and fishermen aboard vessels of the Bureau of Commercial Fisheries Biological Laboratory in Honolulu from 1950 to 1961 are summarized in a series of 12 charts. Each chart covers a 3-month period and shows the hours scouted and the sightings per 10 hours of scouting for total bird flocks, total fish schools, and skipjack tuna schools within areas measuring 5 degrees of latitude by 5 degrees of longitude. Seasonal and areal differences in rate of sighting are apparent, with the highest rates appearing in the vicinity of the Marquesas Islands in the South Pacific Ocean.

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FISH SCHOOLS AND BIRD FLOCKS IN THE CENTRAL PACIFIC OCEAN, 1950-1961

By

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INTRODUCTION

A major objective of many cruises of the Bureau of Commercial Fisheries research vessels operated by the Biological Laboratory in Honolulu has been to investigate the distribution of tunas in the central Pacific. The presence of tunas in oceanic areas is detected by use of various fishing techniques and by visual observations of schools. The presence of tuna schools at the surface is often signaled by closely associated bird flocks which feed on the same small forage organisms that are at the surface or are driven to the surface, presumably by feeding tuna. The bird flocks are visible at a greater distance than the fish schools and are therefore often utilized by fishermen to locate schools.

Between 1950 and 1961, vessels of the Honolulu Laboratory and Laboratory-chartered vessels made 177 cruises in waters of the Pacific Ocean generally bounded by the American west coast, latitudes 20° S. and 50° N., and longitude 165° E. (fig. 1). These cruises were for the purpose of exploring the distribution and abundance of fish, especially tuna, and to collect oceanographic data pertinent to the environment in which tuna live. With few exceptions, a watch was routinely kept for fish schools and bird flocks, and all sightings were recorded.

This report summarizes by time-area units the sightings made during 128 of these cruises (table 1) within that portion of the total area bounded by latitudes 20° S. and 30° N., and longitudes 110° W. and 180° (fig. 1). It was within this area that the major amount of effort was expended and the major portion of the schools and flocks observed.

METHODS

A general method of searching for fish schools, often referred to as "scouting," was followed from 1950 to 1961. Royce and Otsu (1955) described this method in detail and presented an evaluation of its efficiency. Briefly, the vessel's crewman on wheel watch maintained a lookout during daylight hours for birds and other signs of fish schools and recorded his observations. The information recorded included date, time, position of the vessel at time of observation, estimates of the number of birds in the flocks, general types of birds, and if fish were associated with the birds, the species of fish, size of fish, and size of the school. The crewmen were, for the most part, experienced fishermen, who could distinguish bird flocks at distances up to 4 miles and at closer range identify the various birds and fish encountered in the central tropical and subtropical Pacific. In addition to maintaining a record of the flocks of birds and schools of fish, the crewmen also kept count of the numbers of individual fish, scattered birds, and aquatic mammals sighted.

Groups of birds were designated as flocks or as scattered birds on the basis of their behavior. A flock, ranging in numbers from a few to several hundred individuals, behaves as a unit,

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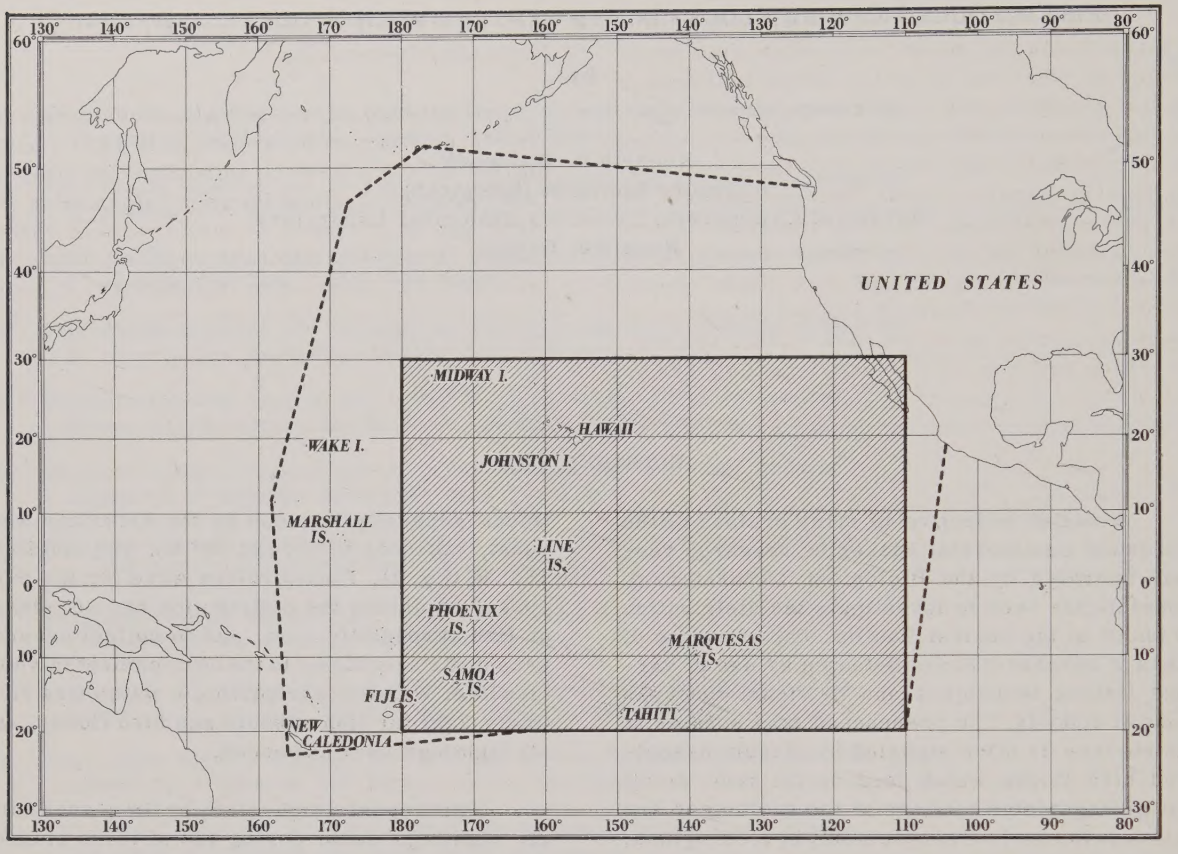

Figure 1.--Operational area for vessels of the Biological Laboratory, Honolulu (broken line) and area included in this summary of bird flock and fish school sightings (solid line)

traveling and feeding together, and is often associated with a school of fish. Flocks of birds appear to be temporary aggregations, often attracted to a common locality by a concentration of food organisms. It is not uncommon for a flock to form within minutes where previously only scattered birds were seen. Flocks also disperse with almost the same rapidity into widely separated, scattered birds.

The size of flocks, except in the case of those with few birds, was an estimated number, the accuracy of which depended upon the experience of the fisherman making the estimate. Also, identification of the types of birds in a flock was often based on the action of the birds, i.e. wing beat, size, height above water, flight path, etc., rather than upon a close examination.

The presence of fish near a bird flock was often only assumed from the behavior of the birds, especially during cruises in which fishing for surface-schooled fish was incidental to other duties. On cruises in which live-bait fishing was a major activity most of the schools were chased and fish were either caught or observed at close range; such cruises comprised about 40 percent of those included in this report. It was not possible in preparing this summary to separate schools of fish which had been detected by these two methods, so the numbers of total schools listed include both schools which were actually seen and those whose presence was deduced from the behavior of a bird flock.

Table 1.--Vessels, cruises, and periods covered by this summary of visual observations of bird flocks and fish schools

Vessel	Cruises	Period
Charles H. Gilbert	1, 3, 6-8, 11-36, 38-54	May 1952-December 1961
Commonwealth	3, 4, 5	May 1955-October 1955
Hugh M. Smith	8-12, 14-47, 50, 51, 52	January 1951-June 1959
John R. Manning	4, 6-9, 11-38	October 1950-December 1957
North American	1, 2	January 1954-May 1954

Positive identification of the species within schools could be made only when fish were caught or when the school could be approached closely enough so that the fish were clearly visible. At times fish were not caught or could not be approached, either because of their behavior or because live-bait fishing was not included in the cruise activities. In such instances it was often possible to identify the species of fish by the action of the associated bird flock. Some error in the numbers of schools of different species may be attributed to this method of identification; however, Royce and Otsu (1955) stated that identification based on this method was "remarkably accurate."

During the early 1950's observations were recorded on a variety of forms. In 1954 special log forms (fig. 2) were introduced to simplify recording the various items of information desired and to increase the uniformity of observations made on different cruises. A second form (fig. 3), designed to facilitate the transfer of data to IBM punched cards, replaced the 1954 version in 1961.

OCCURRENCE OF TUNA SCHOOLS, BIRDS, AND AQUATIC MAMMALS B6.1.1

M/V _____ Cruise _____ Date _____ Noon Position _____

At/en route from _____ to _____

Time: Began Watch																	
(LST) Ended Watch																	
Observer's Name																	
TIME (LST)																	
Tuna Schools	Kind (if obvious)	yellowfin															
		skipjack															
		little tuna															
		unidentified															
	Size of school	small															
		medium															
		large															
		undetermined															
	Est. size of fish (lbs.)																
	No birds with school																
Bird Flocks	Size of flock	10 or less															
		11 - 50															
		50 or more															
	Kinds in flock	terns															
		boobies															
		bo'sun birds															
		frigate birds															
		petrels or shearwaters															
		other															
	No tuna in evidence																
Scattered birds	Give number for each kind	albatross															
		petrels or shearwaters															
		boobies															
		terns															
		frigate birds															
		bo'sun birds															
		storm petrels															
Porpoise	Give number																
	No tuna in evidence																
Other Animals																	

JEK 4/1/54

Figure 2.--Log used to record visual observations of tuna schools, birds, and aquatic mammals, 1954-60

OCCURRENCE OF BIRDS, AQUATIC MAMMALS & FISH SCHOOLS LOG

1	2
0	3

VESSEL: _____ | 3 | 4 | 5 |

CRUISE NUMBER | 6 | 7 | 8 | 9 |

LOCAL MONTH | 10 | 11 |

LOCAL DAY | 12 | 13 |

LOCAL YEAR | 14 | 15 |

LOCAL TIME BEGAN WATCH				
ENDED WATCH				
OBSERVER				

REMARKS:

TIME ZONE _____ 80

BIRD FLOCK & FISH SCHOOLS (ENTER TIME AND POSITION OF EACH BIRD FLOCK AND/OR FISH SCHOOL. CHECK "✓" COMPOSITION OF FLOCK)

LOCAL TIME				OCTANT	LATITUDE				LONGITUDE				SIZE FLOCK	(CODE)	SOOTY TERN	NODDY TERN	WHITE TERN	BOOBY	TROPIC BIRD	FRIGATE BIRD	PETREL SHEARW.	STORM PETREL	ALBATR.	OTHER	FISH SCHOOLS: KIND (WRITE IN)		AVERAGE POUNDS FISH		SIZE SCH.	SCHOOL CHASED P.	BAIT CHUMMED P.	FISH CAUGHT P.	TIME SCOUTING RESUMED
16	17	18	19	20	21	22	23	24		25	26	27	28		32	33	34	35	39	40	41	42	43	44	45		62	63	64	65	66	67				
						°		'			°		'																					

SCATTERED BIRDS, MAMMALS, ETC. (TALLY BY 4-HOUR PERIODS)

	0400-0800 (0800 POS'N)								0800-1200 (1200 POS'N)								1200-1600 (1600 POS'N)								1600-2000 (2000 POS'N)							
	21	22	23	24		25	26	27	28	21	22	23	24		25	26	27	28	21	22	23	24		25	26	27	28	21	22	23	24		25	26	27	28
		°		'			°		'		°		'			°		'		°		'			°		'		°		'			°		'
SOOTY TERN									46									46									46								46
NODDY TERN									47									47									47								47
WHITE TERN									48									48									48								48
BOOBY									52									52									52								52
TROPIC BIRD									53									53									53								53
FRIGATE BIRD									54									54									54								54
PETREL SHEARWATER									55									55									55								55
STORM PETREL									56									56									56								56
ALBATROSS									57									57									57								57
OTHER BIRDS									58									58									58								58
WHALES									59									59									59								59
PORPOISES									60									60									60								60
SEALS									61									61									61								61
OTHER								68	69 70								68	69 70							68	69 70							68	69 70
WRITE IN OCCURRENCES OF FLOATING OBJECT, SIZE AND TYPE.									71									72									73								74
	NO. HOURS WATCHED									NO. HOURS WATCHED									NO. HOURS WATCHED									NO. HOURS WATCHED								

Figure 3.—Log used to record visual observations of tuna schools, birds, and aquatic mammals, 1961 to present

HANDLING OF DATA

By 1960 the amount of data included in the bird flock-fish school logs, as well as in other observational logs, had become so large as to make it inefficient to prepare summaries using hand sorting and computing methods. Because of this a program was begun to place all Laboratory data on IBM punched cards. Figure 4 shows the format used, as well as the items entered on these cards, for the bird flock-fish school observations.

Data pertinent to the sighting of each bird flock and fish school, including the exact position, were placed on a separate card, using card columns 1-45 and 62-67. The number of hours watched, i.e. scouting time, together with data on numbers and types of scattered birds and aquatic mammals seen, were entered on other cards, using columns 1-28, 46-61, and 68-74. Such cards were prepared for each of the four daytime ship's watch periods--0400-0800, 0800-1200, 1200-1600, and 1600-2000 hours--in which there was some scouting effort. The position assigned to these observations was the position of the vessel at the end of the watch period.

Summaries of portions of the data contained in the card decks were prepared for discrete time and area units using standard IBM accounting machines. The time-area units used were periods of one calendar month and the areas measured 1 degree of latitude by 1 degree of longitude. For

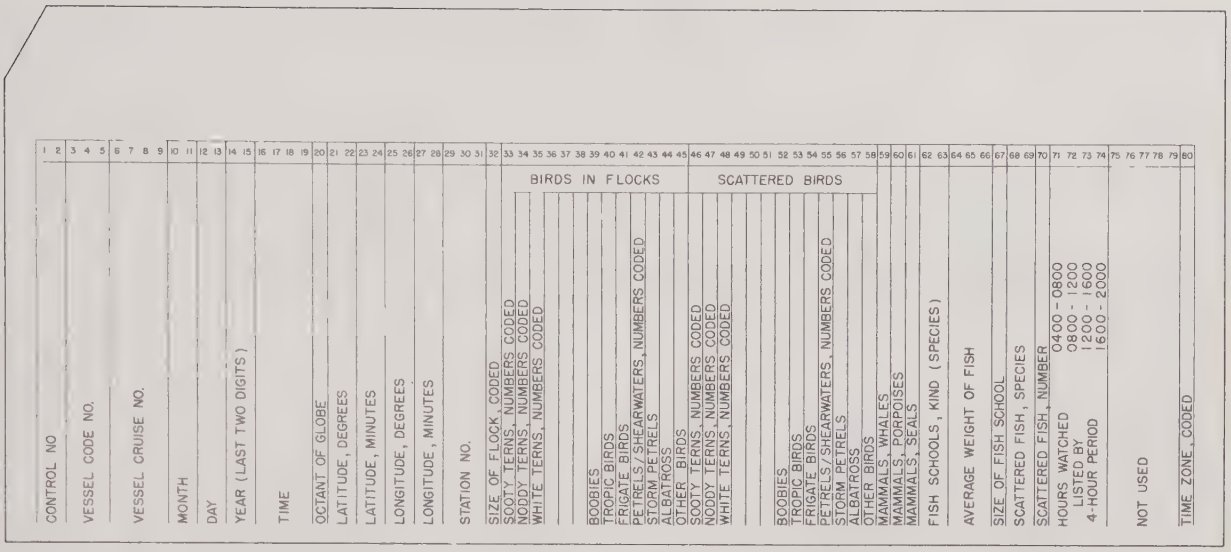
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
BIRDS IN FLOCKS
SCATTERED BIRDS
CONTROL NO
VESSEL CODE NO.
VESSEL CRUISE NO.
MONTH
DAY
YEAR (LAST TWO DIGITS)
TIME
OCTANT OF GLOBE
LATITUDE, DEGREES
LATITUDE, MINUTES
LONGITUDE, DEGREES
LONGITUDE, MINUTES
STATION NO.
SIZE OF FLOCK, CODED
SOOTY TERNS, NUMBERS CODED
NODDY TERNS, NUMBERS CODED
WHITE TERNS, NUMBERS CODED
BOOBIES
TROPIC BIRDS
FRIGATE BIRDS
PETRELS / SHEARWATERS, NUMBERS CODED
STORM PETRELS
ALBATROSS
OTHER BIRDS
SOOTY TERNS, NUMBERS CODED
NODDY TERNS, NUMBERS CODED
WHITE TERNS, NUMBERS CODED
BOOBIES
TROPIC BIRDS
FRIGATE BIRDS
PETRELS / SHEARWATERS, NUMBERS CODED
STORM PETRELS
ALBATROSS
OTHER BIRDS
MAMMALS, WHALES
MAMMALS, PORPOISES
MAMMALS, SEALS
FISH SCHOOLS, KIND (SPECIES)
AVERAGE WEIGHT OF FISH
SIZE OF FISH SCHOOL
SCATTERED FISH, SPECIES
SCATTERED FISH, NUMBER
HOURS WATCHED LISTED BY 4-HOUR PERIOD
0400 - 0800
0800 - 1200
1200 - 1600
1600 - 2000
NOT USED
TIME ZONE, CODED

Figure 4.--Format of punch card and items of information concerning the results of visual scouting entered on cards

each such unit the following items were summed and printed:

1. Number of bird flocks (total and by four size categories)

2. Number of schools of fish (skipjack, yellowfin, skipjack-yellowfin mixed, flying fish, unidentified fish, and total fish schools)

3. Total schools with and without accompanying bird flocks

4. Skipjack schools with and without bird flocks

5. Bird flocks without schools of fish

6. Number of hours watched (total and by each of four watch periods)

7. Number of scattered birds by type (This number is coded and is only an approximation of the real numbers observed.)

This report summarizes only a portion of the above items, viz., (1) total bird flocks, (2) total fish schools, (3) skipjack schools, (4) total yellowfin schools, and (5) total number of hours watched.

An examination of the degree-month sums for these categories indicated that sufficient data were not available to permit an ocean-wide summary based on such small units. Because of this the data were combined into larger time-area units of 3 months and 5° x 5° areas. The quarterly periods selected were December-February, March-May, June-August, and September-November. This grouping was chosen so that June, July, and August, the months during which maximum catches are made in the Hawaiian skipjack fishery, would comprise one quarter. The 5° x 5° areas were chosen arbitrarily by starting at the Equator and longitude 110° W., the eastern boundary of the summary area, and proceeding by 5° increments of latitude and longitude northward and westward in the Northern Hemisphere and southward and westward in the Southern Hemisphere. Areas in the Northern Hemisphere were designated by the latitude and longitude of the southeast corner and in the Southern Hemisphere by the northeast corner of the 5° square.

Within each 3-month-5° x 5° time-area unit four items were summed--number of bird flocks, number of skipjack schools, number of schools of all fish, and number of hours scouted. From these figures the rates of sighting were computed in terms of numbers of flocks or schools sighted per 10 hours of scouting.

For the area outside of the hatched portion of figure 1, but within the broken lines, only summaries for quarters of the year are presented (table 2).

Table 2. --Summary by quarter of the year of the total numbers and numbers per 10 hours of scouting for bird flocks, total fish schools, skipjack schools, and yellowfin schools in major sectors of the survey area

Period	Hours scouted	Bird flocks	Bird flocks/10 hours	Fish schools	Fish schools/10 hours	Skipjack schools	Skipjack schools/10 hours	Yellowfin schools	Yellowfin schools/10 hours	Hours scouted	Bird flocks	Bird flocks/10 hours	Fish schools	Fish schools/10 hours	Skipjack schools	Skipjack schools/10 hours	Yellowfin schools	Yellowfin schools/10 hours
	Area: 0°-30° N., 110° W.-180°									Northern Hemisphere outside of 0°-30° N., 110° W.-180°								
Dec. - Feb.	4,907	661	1.35	387	.79	100	.20	37	.08	878	2	.02	0	.00	0	.00		
Mar. - May	6,878	1,248	1.82	703	1.02	294	.43	42	.06	1,184	170	1.44	16	.14	0	.00		
June - Aug.	5,801	1,794	3.09	1,393	2.40	396	.68	35	.06	2,327	80	.34	13	.06	1	.00		
Sept.- Nov.	5,895	998	1.69	549	2.93	189	.32	37	.06	1,510	109	.72	16	1.06	6	.04		
Total	23,481	4,701	2.00	3,032	1.29	979	.42	151	.06	5,899	361	.61	45	.08	7	.01		
	Area: 0°-20° S., 110° W.-180°									Southern Hemisphere outside of 0°-20° S., 110° W.-180°								
Dec. - Feb.	1,773	787	4.44	585	3.30	222	1.25	23	.13	13	1	.77	1	.77	0	.00		
Mar. - May	1,583	732	4.62	468	2.96	162	1.02	12	.08	0	0	.00	0	.00	0			
June - Aug.	600	198	3.30	76	1.27	46	.77	13	.22	0	0		0		0			
Sept.- Nov.	1,767	659	3.72	299	1.69	115	.65	15	.08	0	0		0		0			
Total	5,723	2,376	4.15	1,428	2.49	545	.95	63	.11	13	1	.77	1	.77	0			
	Total: 20° S.-30° N., 110° W.-180°																	
	29,204	7,077	2.42	4,460	1.53	1,524	.52	214	.07									
	GRAND TOTAL									35,116	7,439	2.12	4,506	1.28	1,531	.44	214	.06

RESULTS

Results of these tabulations are shown in charts 1-12, with a broad summary presented in table 2.

Three features of the distributions shown in the charts are quite apparent: (1) high rates of sighting were most prevalent in time-area units containing island groups, (2) there were distinct seasonal changes in rates of sighting, and (3) the rate of sighting in the general Marquesas area was much higher than for any other area of similar size.

Surface schools of fish and bird flocks were almost completely absent between latitudes 25° and 30° N. except near Midway Islands. To the east of the Hawaiian Islands flocks and schools were also scarce, and a definite band of low abundance could be noted between the Hawaiian and Line Islands in the vicinity of latitudes 10° N. - 15° N.

A distinct seasonal trend can be seen in the occurrence of flocks and schools near the Hawaiian and Marquesan Islands (fig. 5). As might be expected (Yamashita, 1958; Wilson and Austin, 1959), the highest rates of sighting in the Hawaiian area were in the June-August quarter, while in the Marquesan area they were highest in the December-February quarter. In the Line Islands area, just north of the Equator, seasonal changes were less marked and somewhat irregular. Bird flocks were most abundant during June-August (as in the Hawaiian Islands), total fish schools were most numerous during December-February (as in the Marquesas Islands), and a poorly defined maximum for skipjack schools occurred in September-November.

Maximum rates of sighting per 10 hours of scouting for any single 5°-quarterly unit in the Marquesan area were 8.16 bird flocks (in June-August), 3.00 skipjack schools (December-February), and 6.86 total fish schools (December-February). By contrast maximum rates for these categories of sightings in the Hawaiian area were 6.17 bird flocks, 1.27 skipjack schools, and 5.42 total fish schools, all in the June-August quarter.

Total scouting effort recorded from 1950 to 1961 was 35,116 hours, about 84 percent of which was expended in the Northern and 16 percent in the Southern Hemisphere. All but 13 hours in the Southern and 80 percent of the time in the Northern Hemisphere, a total of 29,204 hours, were spent in the summary area shown in charts 1-12. Total sightings, exclusive of aquatic mammals and scattered birds, consisted of 7,439 bird flocks and 4,506 fish schools. Of the latter, 1,531 were skipjack schools, 214 were yellowfin

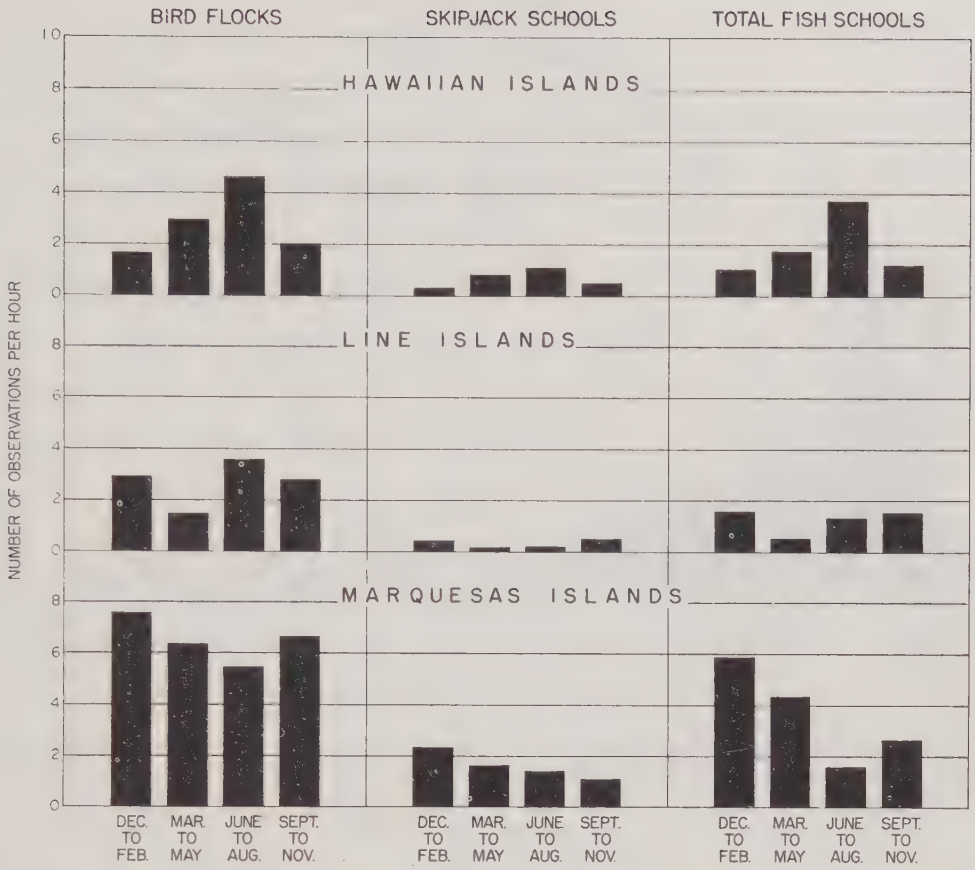

Figure 5.--Seasonal variation in rate of sighting for three major island groups

schools, and the remainder were mostly schools whose species composition could not be identified. As can be seen in table 2 about three-fourths of the schools were sighted in the Northern Hemisphere and one-fourth in the Southern Hemisphere.

Within the summary area the amount of effort reported for any 5°-quarterly unit ranged from 1 to 2,160 hours with a mode, based on 10-hour groupings, of 10-19 hours. Three areas received the major portion of the effort, the Hawaiian and Line Islands areas in the North Pacific and the Marquesan-Tuamotu Islands area in the South Pacific. Effort was distributed about evenly among the four quarters of the year in the northern sector of the summary area, but in the southern sector effort during June-August was only about half that of any other quarter.

About 95 percent of the flocks, 99 percent of the total schools, and 99 percent of the skipjack schools were sighted within the summary area (fig. 1). Approximately one-third of the sightings but only one-fifth of the effort were in the South Pacific, with the result that the rates of sighting of flocks and schools in that area were much higher than in the North Pacific. Taken by 5°-quarterly units, the modal rate of sighting was zero. However, this was due largely to the high incidence of zero sightings for areas in which less than 30 hours of effort had been expended (fig. 6). Because of this, squares with less than 30 hours of effort appear unshaded in the charts as an indication that the amount of effort was insufficient to accurately assess the abundance of flocks and schools.

Only 214 schools of yellowfin tuna were sighted during the 12-year period, about 5 percent of the total schools. As shown in table 2, they were seen at all seasons of the year in about equal numbers, and in both the North and the South Pacific. Because of the low numbers sighted, charts were not prepared for this species.

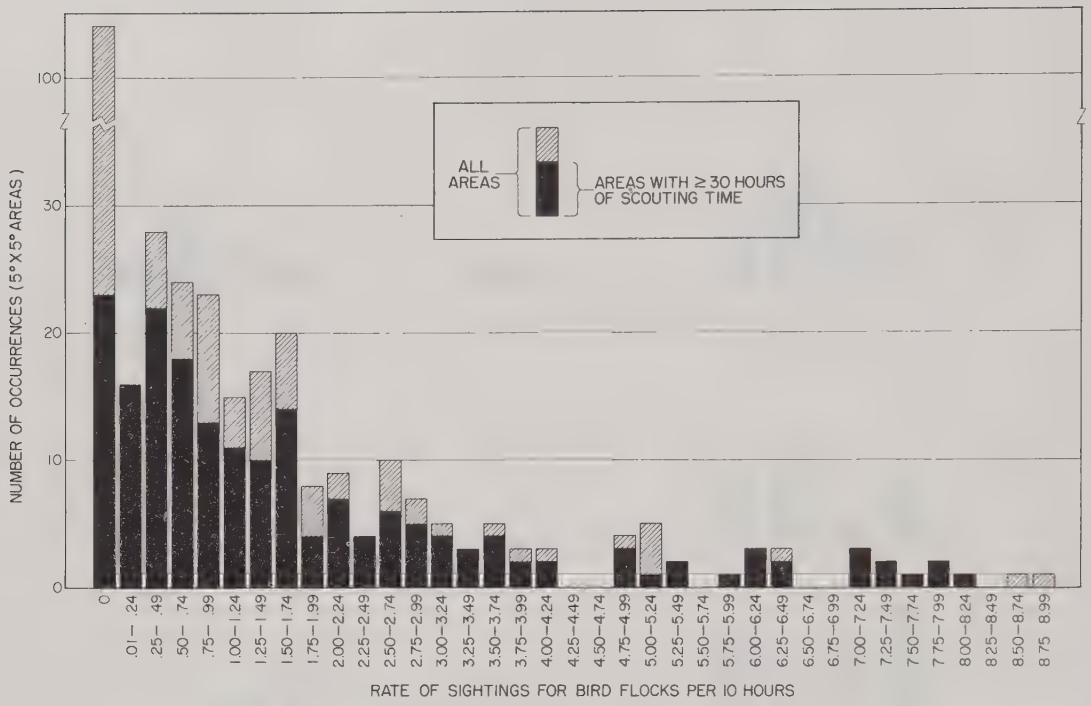

Figure 6.--Frequency of occurrence of different sighting rates of bird flocks in 5° x 5°-quarterly units

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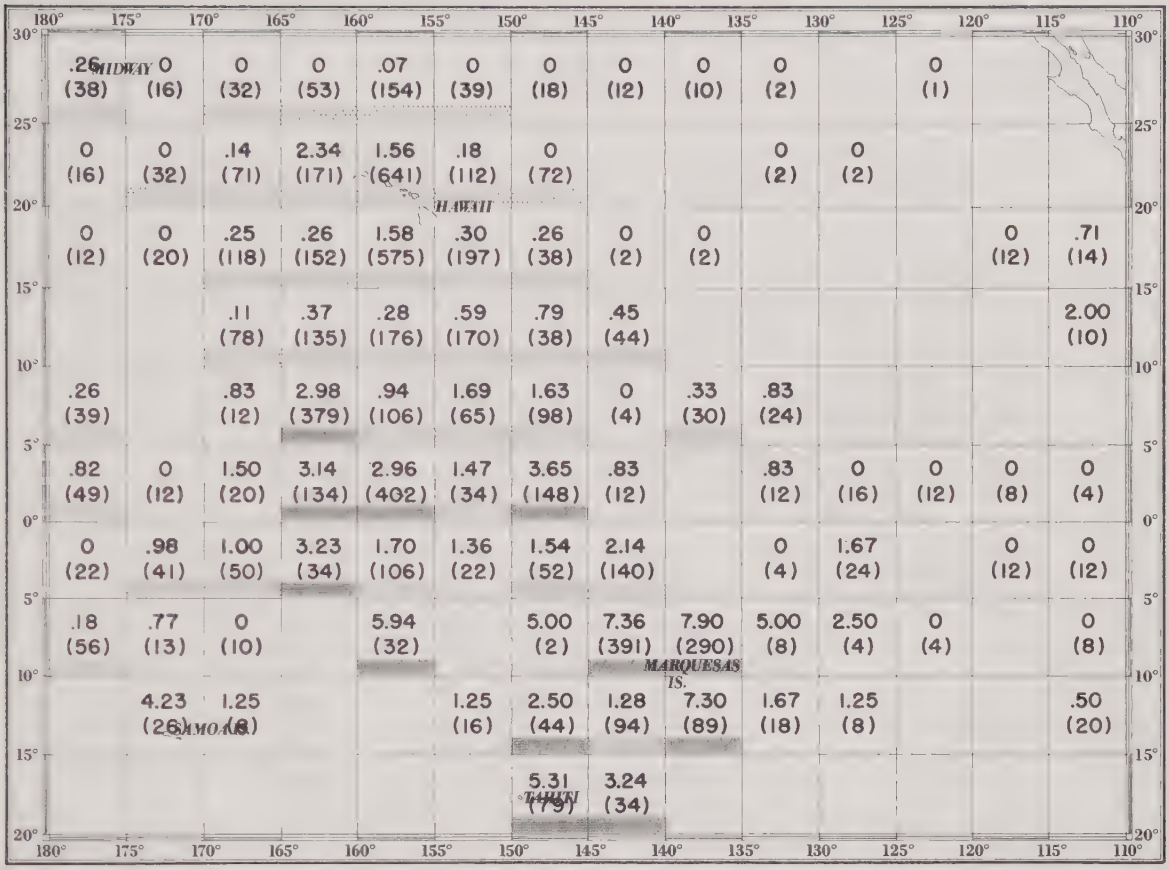
BIRD FLOCKS

CHART I

DECEMBER TO FEBRUARY



SIGHTINGS PER 10 HOURS OF SCOUTING

- LESS THAN 0.25
- 0.25 – 2.50
- GREATER THAN 2.50

BIRD FLOCKS

MARCH TO MAY

CHART 2

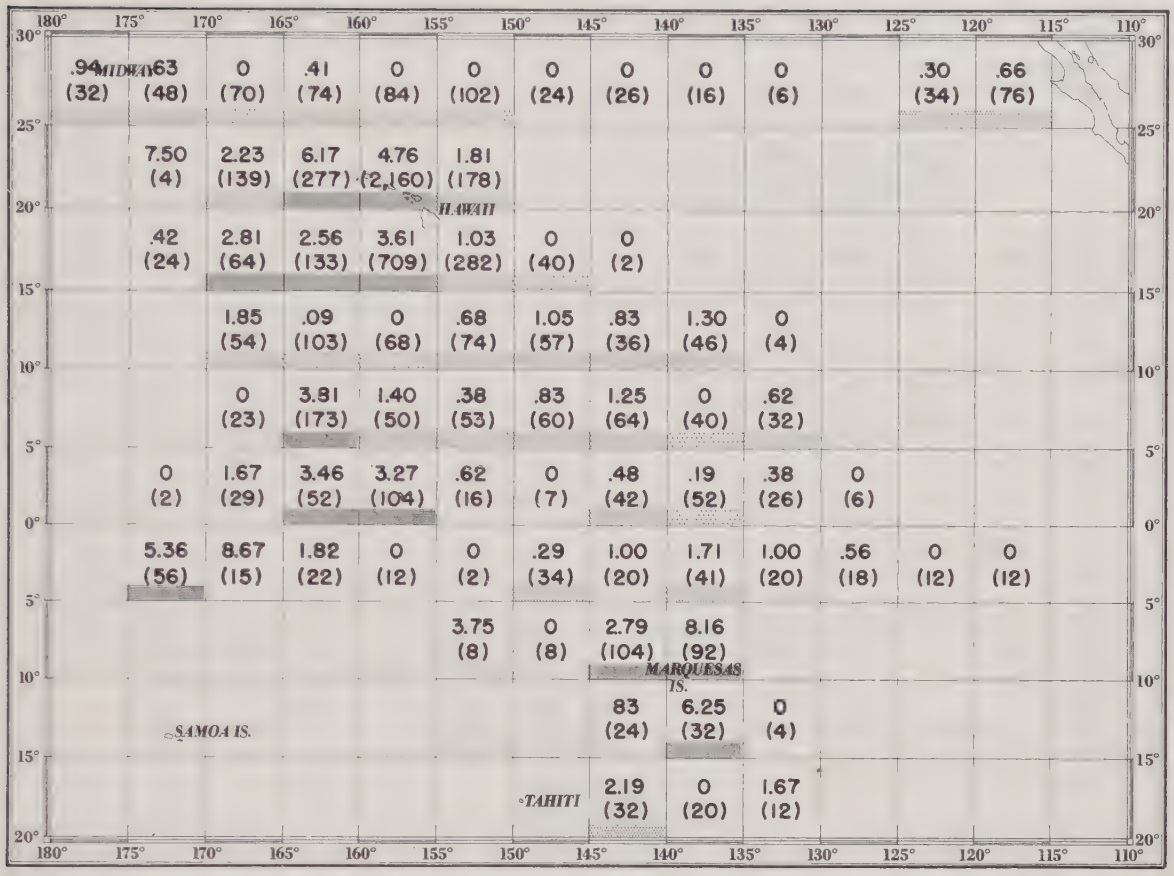
SIGHTINGS PER 10 HOURS OF SCOUTING

- LESS THAN 0.25
- 0.25 – 2.50
- GREATER THAN 2.50

BIRD FLOCKS

CHART 3

JUNE TO AUGUST



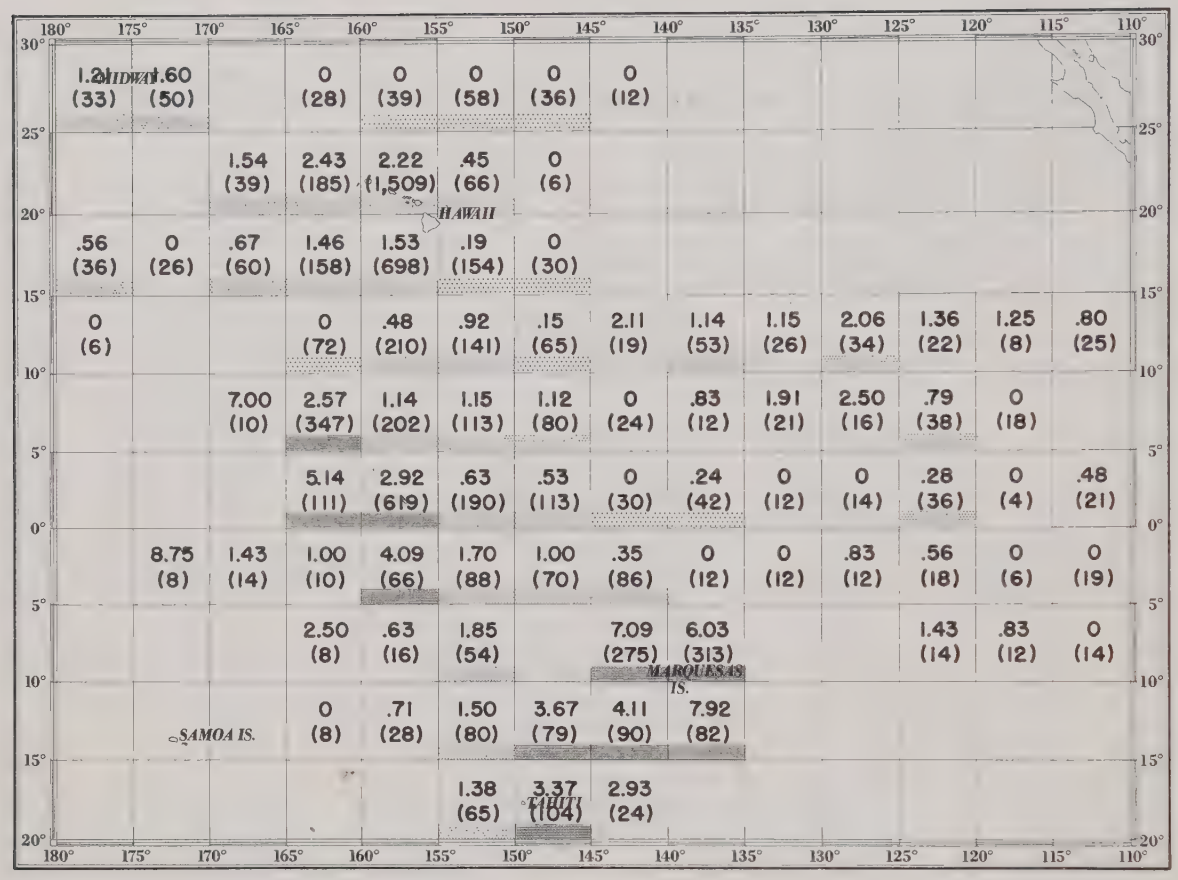
SIGHTINGS PER 10 HOURS OF SCOUTING

- LESS THAN 0.25
- 0.25 - 2.50
- GREATER THAN 2.50

BIRD FLOCKS

CHART 4

SEPTEMBER TO NOVEMBER



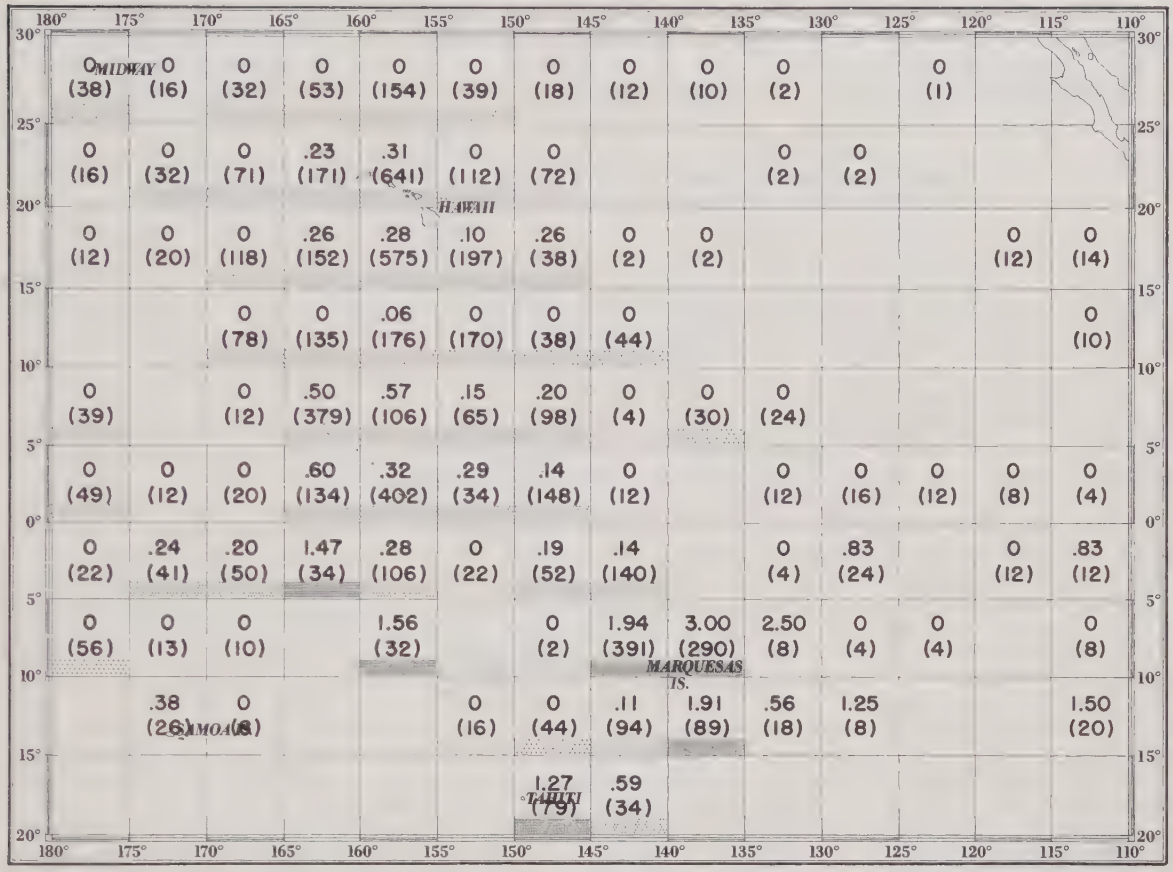
SIGHTINGS PER 10 HOURS OF SCOUTING

- LESS THAN 0.25
- 0.25 - 2.50
- GREATER THAN 2.50

SKIPJACK SCHOOLS

CHART 5

DECEMBER TO FEBRUARY



SIGHTINGS PER 10 HOURS OF SCOUTING

- LESS THAN 0.10
- 0.10 – 1.00
- GREATER THAN 1.00

SKIPJACK SCHOOLS

CHART 6

MARCH TO MAY

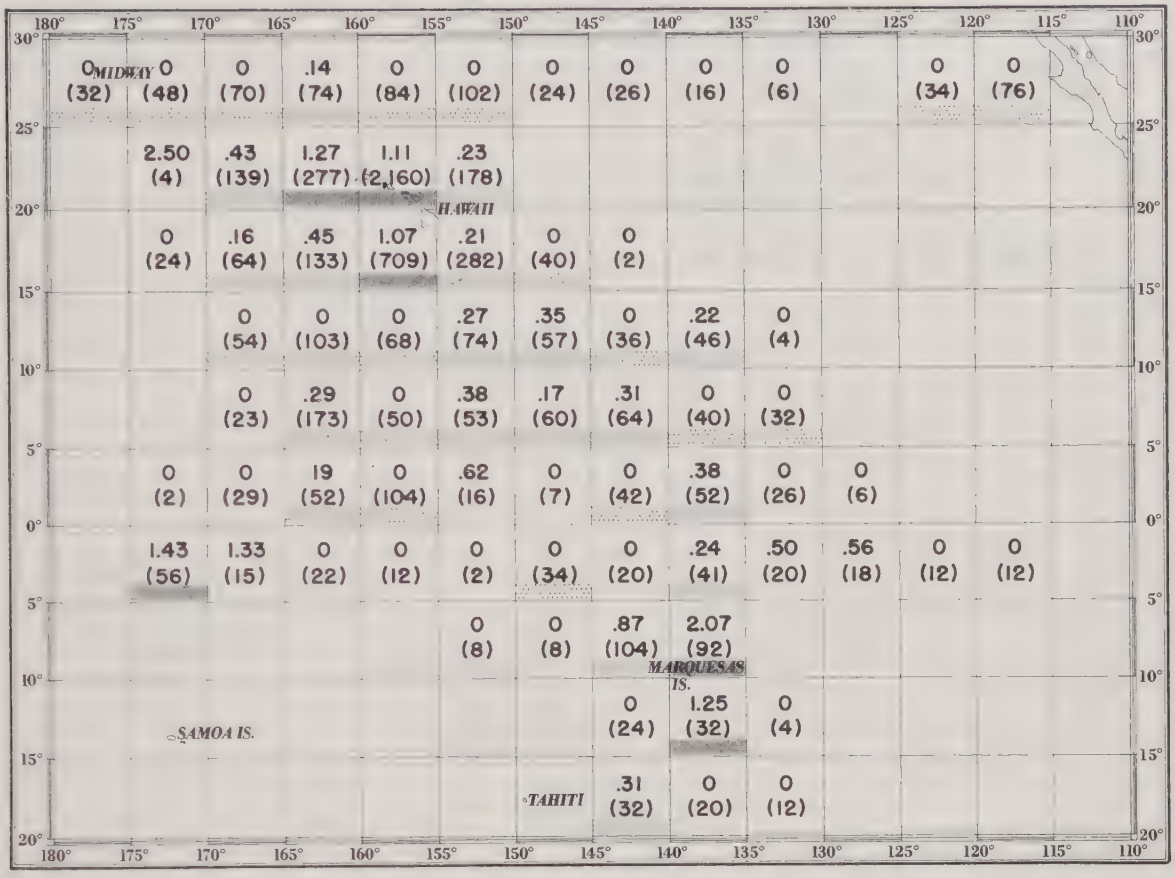
SIGHTINGS PER 10 HOURS OF SCOUTING

- LESS THAN 0.10
- 0.10 – 1.00
- GREATER THAN 1.00

SKIPJACK SCHOOLS

CHART 7

JUNE TO AUGUST



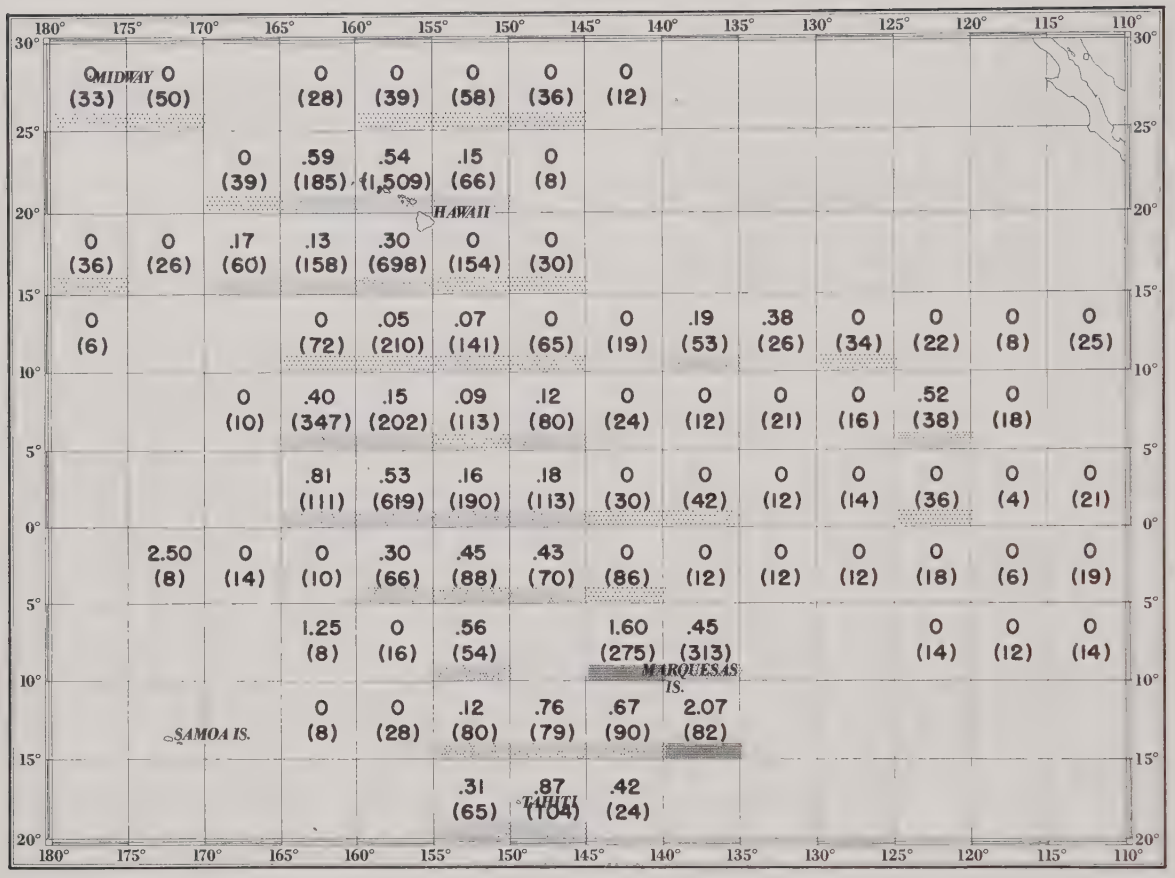
SIGHTINGS PER 10 HOURS OF SCOUTING

- LESS THAN 0.10
- 0.10 – 1.00
- GREATER THAN 1.00

SKIPJACK SCHOOLS

CHART 8

SEPTEMBER TO NOVEMBER



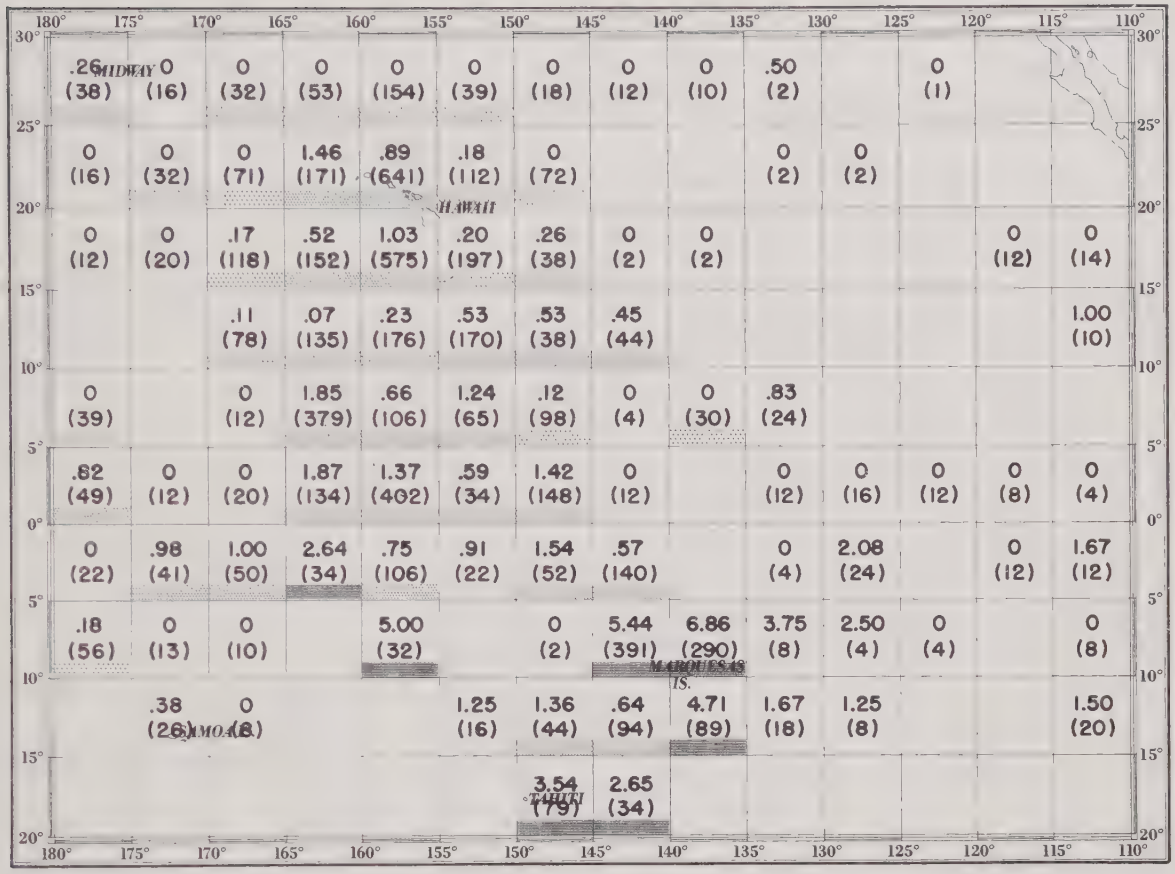
SIGHTINGS PER 10 HOURS OF SCOUTING

- LESS THAN 0.10
- 0.10 – 1.00
- GREATER THAN 1.00

TOTAL SCHOOLS

CHART 9

DECEMBER TO FEBRUARY



SIGHTINGS PER 10 HOURS OF SCOUTING

- LESS THAN 0.25
- 0.25 - 2.50
- GREATER THAN 2.50

TOTAL SCHOOLS

MARCH TO MAY

CHART 10

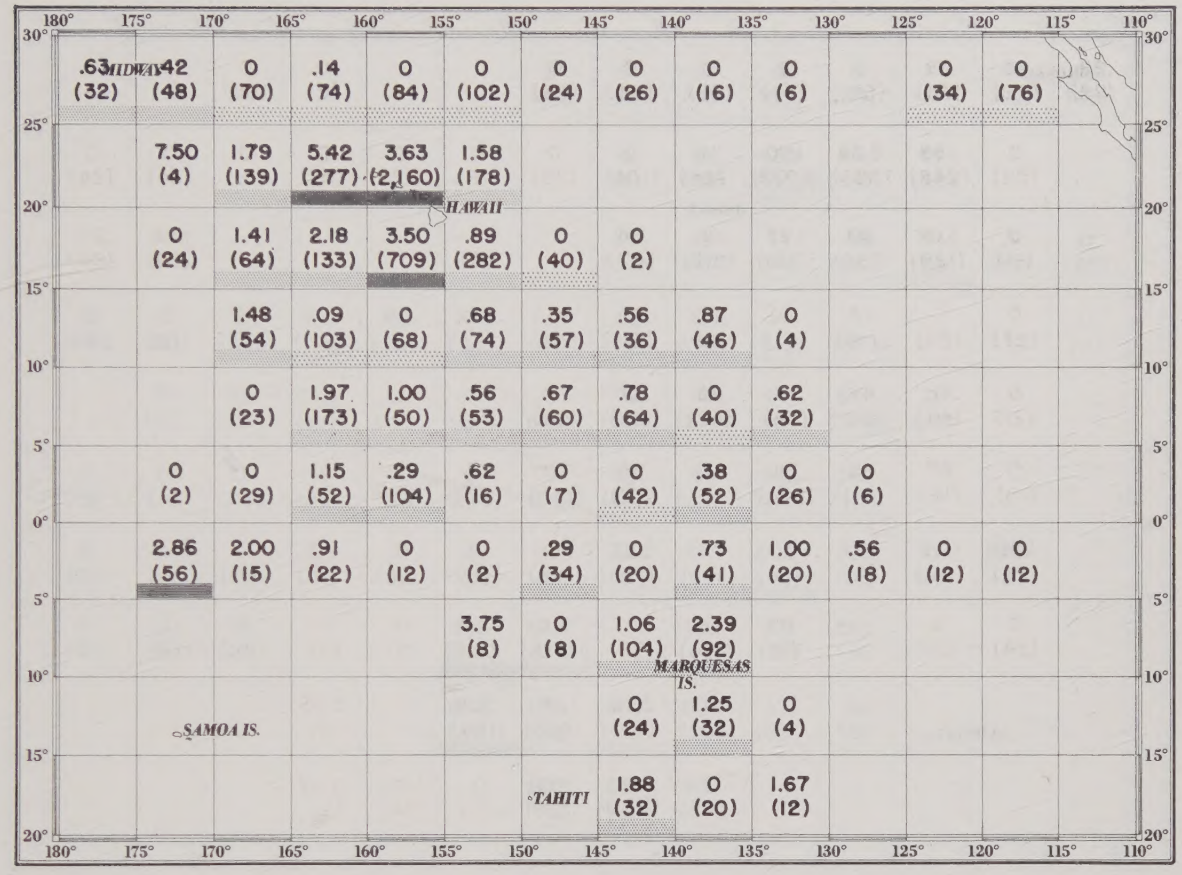
SIGHTINGS PER 10 HOURS OF SCOUTING

- LESS THAN 0.25
- 0.25 – 2.50
- GREATER THAN 2.50

TOTAL SCHOOLS

CHART 11

JUNE TO AUGUST



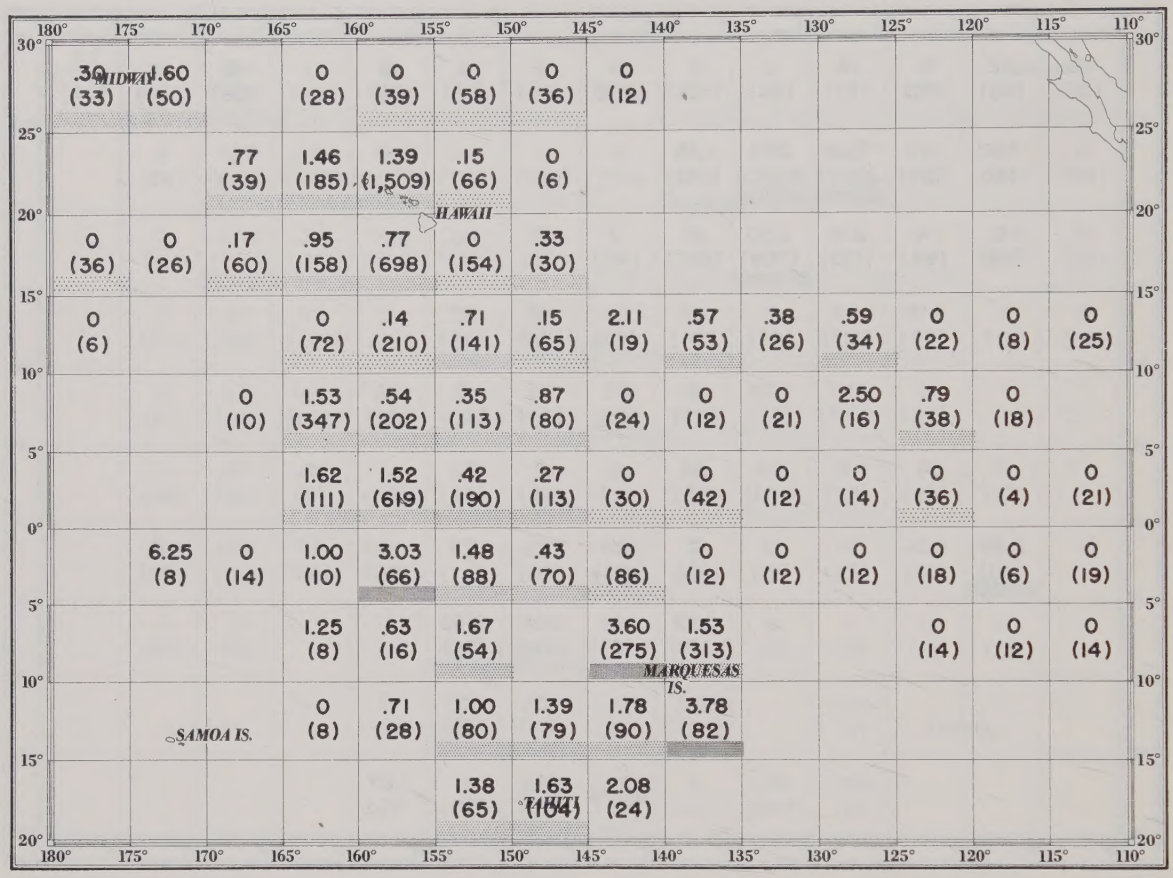
SIGHTINGS PER 10 HOURS OF SCOUTING

- LESS THAN 0.25
- 0.25 - 2.50
- GREATER THAN 2.50

TOTAL SCHOOLS

CHART 12

SEPTEMBER TO NOVEMBER



SIGHTINGS PER 10 HOURS OF SCOUTING

- LESS THAN 0.25
- 0.25 - 2.50
- GREATER THAN 2.50